VI. *Part of a* LETTER *from Mr.* Caſwell of Oxford, *F. R. S. to the Reverend Mr* Flamſteed, *M. R. S. S. giving an account of a new Baroſcope, invented by him, and communicated by Mr* Hodgſon, *F. R. S.*

SIR,

I Have made a new Sort of Baroſcope, 'tis cheap and very exact, I here ſend you its Calculation as it occurr'd to my Thoughts before I made it. Suppoſe ABCD is a Bucket of Water, in it the Baroſcope $xrezyosm$ which conſiſts of a Body $xrsm$, and a Tube $ezyo$, the Body and Tube are both concave Cylinders communicating with each other, and made of Tin (for want of Glaſs:) The Bottom of the Tube zy has a Lead-weight to ſink it, ſo that the Top of the Body may juſt ſwim even with the Surface of the Water by the Addition of ſome Grain-weights on the Top. The Water when the Inſtrument is forc'd with its Mouth downwards gets up into the Tube to the height yu. There is added on the Top a ſmall concave Cylinder, which I call the Pipe, to diſtinguiſh it from the bottom ſmall Cylinder, which I call the Tube: This Pipe is to ſuſtain the Inſtrument from ſinking to the Bottom, md is a Wire ms, de are two Threads oblique to the Surface of the Water, which Threads perform the Office of Diagonals: For that while the Inſtrument ſinks more or leſs by the Alteration of the Gravity of the Air, there where the Surface of the Water cuts the Thread, is form'd a ſmall Bubble which Bubble aſcends up the Thread while the ☿ of the common Baroſcope aſcends.

The Circumference of the Body is 21 Inches, therefore its Area = 35: the Altitude ms = 4, therefore the Bo-

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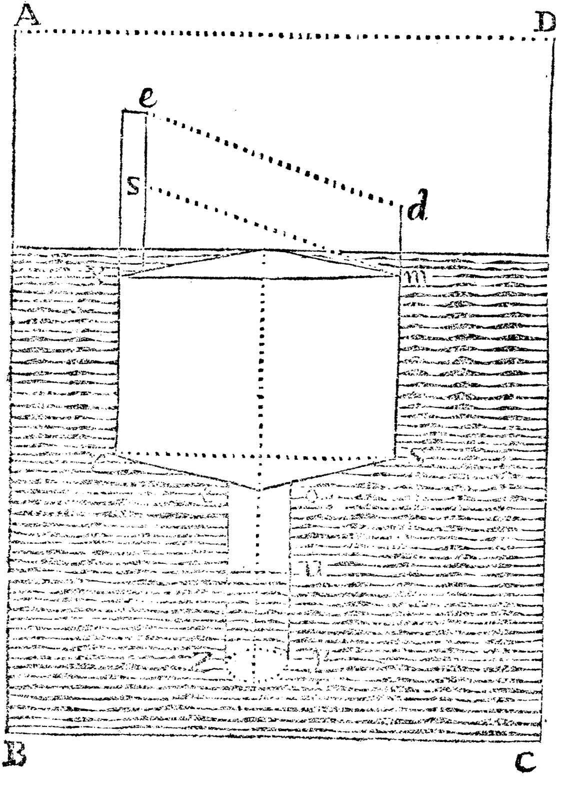
dy's Solidity = 140, each Baſe $x m$, $r s$, has a Convexity whoſe Altitude is 6.5, therefore the Conoid on each Baſe is nearly = $11\frac{1}{2}$, therefore d the whole Body is = ($140 + 11\frac{1}{2} + 11\frac{1}{2} =$) 163, and b the entire Altitude of the Body = ($4 + .65 + .65 =$) 5.3. The Inner Circumference of the Tube is 5.014, therefore its Area $n = 2$ the Length of the Tube = 4.5, therefore the Tube's Capacity = 9, therefore C, the Content of the Body and Tube = $163 + 9 =$ 172 Cubic Inches, that is almoſt $2\frac{1}{2}$ Quarts.

Suppoſe the Air's Preſſure when greateſt = 30.5 Inches of ☿ = ($30.5 \times 14 =$) 427 of Water, and $f = 427$, therefore $f c = 73444$. Put a for the Depth $o u$, of the Air in the Tube when the Body is juſt all immers'd, the Air in the Inſtrument on Immerſion Contracts ſomewhat by the Cold of the Water; this Contraction I find is nearly as much as would be produc'd by an Addition of 1 Inch to the Atmoſphere's Altitude 427, this in cold Weather, but in warm Weather 'tis probably twice as much: but we will now ſuppoſe it = 1, therefore the Depth of the Surface of the Water in the Tube below the Surface of the outer Water is = $b + a$, therefore the Preſſure on that inner Surface is as the Altitude of the Atmoſphere above it = $f + b + 1 + a = F + a$ (putting $F = f + b + 1$.) Then for that the Spa-



ces into which the Air is contracted, are reciprocal to their reſpective Preſſures, and for that while the Inſtrument is out of the Water the Preſſure f anſwer'd to the Space C therefore, $F+a:f::C:\frac{fc}{F+a}=$ Space which the Air takes up in the Inſtrument under Water; therefore, $\frac{fc}{F+a}-d=$ that Part of the Tube which is poſſeſs'd by Air $=an$ (ſuppoſing the Tube's Area $2=n$). Therefore $fc-Fd-ad=Fan+aan$. Therefore $aa+\overline{F+\frac{d}{n}}\times a=\frac{fc-Fd}{n}$. Put $F+\frac{d}{n}=2g$, therefore $aa+2ga=\frac{fc-Fd}{n}$ therefore $a=\sqrt{:\frac{fc-Fd}{n}+gg}-g$.

Then ſuppoſe the Atmoſphere's Gravity leſs ſo much as to ſink the ☿ $\frac{1}{10}$ Inch $=1.4$ of Water, and therefore putting $\varphi=F-1.4$, and in the laſt Equation α inſtead of a, and γ inſtead of g, You have $\alpha=\sqrt{\frac{fc-\varphi d}{n}+\gamma\gamma}:-\gamma$. Thus I find $\left.\begin{array}{l}a=2.72\\ \alpha=2.94\end{array}\right\}$ and therefore $\alpha-a=.22$, which $.22\times n$ gives .44 Cubic Inches, and (ſuppoſing a Cube-Inch $=$ 253 Grains) $.44\times 253=111$ Grains-weight of Water that was gotten up into the Tube in the 1ſt Caſe more than in the 2d, and therefore the Baroſcope requires an Addition of 111 Grains on its Top to ſink it with the Level of the Water in the 2d Caſe more than in the 1ſt, and this upon the ſinking of the ☿ in the common Baroſcope only $\frac{1}{10}$ Inch; Now 1 Grain in this new Baroſcope is nearly as diſcernable as $\frac{1}{10}$ Inch in the Common, and therefore this new Baroſcope is more exact than the Common 111 Times.

Put $f = 247$. $c = 172$. $d = 163$. $n = 2$ as above, only change F, put F 437.3, that is, ſuppoſe the Body ſunk in Water 4 Inches lower; In this Caſe $\alpha = 208$, therefore $a - \alpha = .64$ which multiplyed into $\varphi n = 1.28$ Cubic-inches, which × 253 gives 324 Grains, and ſo much the Body's Top $x\,m$ being ſunk 4 Inches under Water, the Body becomes heavier, than while $x\,m$ was at the Surface of the Water. Therefore this 1.28 divided by the aforeſaid Depth 4 gives .32 the Area of the Top Pipe ſuch as would ballance or buoy up the Body at any Depth. Strictly ſpeaking the Pipe ſhould be gradually bigger upward in order to ſuſtain the Inſtrument at any Depth, but as to Senſe 'tis Cylindrical, and its Circumference = 2 005. But for that the leaſt Alteration of the Air would make the Body's Top $x\,m$ in that caſe paſs thro' the 4 Inches (which 4 Inches I ſuppoſe all the Variety of Depth that the Inſtrument has room given it in the Bucket to aſcend or deſcend) therefore the Pipe is made a ſmall matter bigger, (*viz.*) its Circumference is 2.14; whereby the Pipe, according as the Body ſinks more, gives more reſiſtance to the deſcending Body. The Pipes Area is .3643: Therefore the Capacity of the Pipe in 4 Inches Altitude is = 1.457. But as aboveſaid to give juſtly no reſiſtance, its Capacity ſhould be 1.28. Therefore this 1.28 taken from 1.457, leaves .177 the actual reſiſtance in 4 Inches depth, *viz.* (.177 × 253 =) 44 Grains.

But this reſiſtance will not be the ſame in all weathers, in order therefore to calculate what it will be when the ☿ of the common Baroſcope is very low: For example, but 28 Inches high = 392 of Water; f muſt be ſuppos'd = 392, therefore $F = f + b + 1 = 398.3$, and the reſt as before; *viz.* $d = 163$, $f\,c = 67424$. $F\,d = 649229$. Thence by the aforeſaid Equation $\left.\begin{matrix} a = 2.59 \\ \alpha = 2.84 \end{matrix}\right\}$ Therefore

$\alpha - a = .25$, which × 2 gives .50 Cubic Inches, which × 253 = 126 Grains. So that this Baroſcope when the ☿ is loweſt, is more exact than the common 126 Times, ſuppoſing the Body immers'd afreſh when the ☿ is ſo low.

Next while the ☿ is ſo very low, ſuppoſe the Top of the Body depreſs'd 4 Inches under Water; therefore $\varphi = F + 4 = 402.3$, the reſt are as before, *viz.* $fc = 67424$, then α will be 1.9: but before, while the Top of the Body was at the Surface, α was 2.59. Therefore the Difference 69 × Tube's Area 2, gives 1.38 Cube-inches, which × 253 gives 349 Grains, and ſo much the Baroſcope is heavier when the Top *xm* is 4 Inches under Water, or which comes to the ſame, ſuppoſing that ☿ at 28, and *xm* at the Surface; this Baroſcope by the ☿'s aſcending $\frac{4}{14}$ Inch will become heavier 349 Grains. The Pipe's Capacity in 4 Inches Altitude was 1.457, from which take the aboveſaid 1.38, the reſidue = .077, which × 253 gives 19 Grains in 4 Inches; ſo that the Pipe will ſuſtain the Baroſcope, and alſo 44 when the ☿ is 30½ high, and but 19 Grains when the ☿ is 28 high. The fewer Grains difference there are in its ſinking, thro' 4 Inches, the more nice the Baroſcope will be.

There where the Thread cuts the Surface of the Water, is form'd a Bubble, therefore this Bubble while the Inſtrument ſinks in Water 4 Inches, which is all the room that I give it, the Bubble moves on the 2 Diagonal Threads 20 Inches, it follows therefore that 120 Grains difference would make the Bubble walk over 120 Inches, if the Threads were ſo long, but as it has been above calculated, about 120 Grains difference of Weight of the Inſtrument is produc'd by ſo much of the Alteration of the Air, as would make the ☿ of the common Baroſcope $\frac{1}{10}$ Inch: therefore when the ☿ aſcends $\frac{1}{10}$ Inch, the Bubble of this new Baroſcope aſcends 120 Inches: therefore this new Baroſcope is more exact than the Common Baroſcope by about 1200 times.

Obſervations made with this new Baroſcope.

1. While the ☿ of the common Baroſcope is often known to be ſtationary 24 hours together, the Bubble of the new Baroſcope is rarely found to ſtand ſtill 1 minute.

2. Suppoſe the Air's Gravity encreaſing, and accordingly the Bubble aſcending, during the Time that it aſcends 20 Inches, it will have many ſhort deſcents, of the Quantity of ½ Inch, 1, 2, 3, or more Inches, each of which being over it will aſcend again. Theſe retroceſſions are frequent, and of all Varieties in quantity and duration, ſo that there is no judging of the general courſe of the Bubble by bare inſpection, though you ſee it moving but by waiting a little time.

3. A ſmall Blaſt of Wind will make the Bubble deſcend; a Blaſt that can't be heard in a Chamber of the Town, will ſenſibly force the Bubble downward. The Blaſts of Wind ſenſible abroad cauſe many of the aboveſaid Retroceſſions, or Accelerations in the general Courſe; as I found by carrying my Baroſcope to a Place where the Wind was Perceptible.

4. Clouds make the Bubble deſcend. A ſmall Cloud approaching to the Zenith works more than a great Cloud near the Horizon. In Cloudy weather the Bubble deſcending, a break of the Clouds (or clear Place) approaching to the Zenith, has made the Bubble to aſcend; and after that break had paſs'd beyond the Zenith a conſiderable Space, the bubble again deſcended.

5. All Clouds (except one) hitherto by me obſerv'd, have made the Bubble to deſcend. But the other day the Wind being *North*, and the Courſe of the bubble deſcend-

deſcending. I ſaw to the Windward a Large thick Cloud near the Horizon, and the bubble ſtill deſcended, but as this Cloud drew near the Zenith it turn'd the way of the bubble making it to aſcend, and the bubble continued aſcending till the Cloud was all paſs'd, after which it reſumed its former deſcent. It was a Cloud that yielded a cold ſhower of ſmall Hail.

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